

The Red-fin Goby, *Evorthodus minutus* Meek & Hildebrand, 1928: a new record from Santa Cruz Island, Galapagos Archipelago

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Abstract

The Red-fin Goby, *Evorthodus minutus* Meek & Hildebrand, 1928, is a coastal brackish species which is commonly distributed from Sinaloa, Mexico to Guayaquil, Ecuador and particularly abundant in mangroves of Central American eastern Pacific. We report a new record of *E. minutus* collected from the Santa Cruz Island, part of the Galapagos Archipelago. This new record represents a range extension and is allows for a relevant discussion about colonization pathways in the equatorial eastern Pacific of a brackish-water species.

Key words

Biodiversity, brackish gobies, fish collections, oceanic island, Tropical Eastern Pacific.

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Introduction

The family Gobiidae is the largest marine fish family with nearly 1,880 species around the world (Fricke et al. 2018). To date, gobies from Tropical Eastern Pacific (TEP) encompass 87 described species that inhabit marine, brackish and freshwater environments of the coastal zone and oceanic islands (Valencia-Méndez et al. 2018) and from shallow to depths that include the twilight zone (e.g. Bussing 1990, 1997). Despite the family's high diversity in the TEP, the group remains poorly studied there, and Valencia-Mendez et al. (2018) noted the existence of large unprospected areas and habitats where additional systematic surveys may still render complete biological inventories.

The genus *Evorthodus* was first diagnosed by Gill (1859), and later by Ginsburg (1931) and Dawson (1967).

According to Pezold (2004) and Cheffe et al. (2010), the synapomorphy that defines the genus are head short, snout profile steeply rounded with 2 pores between eyes, short mouth overhung by snout, and the presence of incisiform teeth in juveniles and females. *Evorthodus* is an American genus, which is included within the tribe Gobiosomatini, a diverse clade that comprises more than 130 species and 27 genera in the western Atlantic and eastern Pacific oceans. They are often referred to as the “American seven-spined gobies”. The genus *Evorthodus* contains 2 species, *Evorthodus lyricus* (Girard, 1858) from western Atlantic and Greater Caribbean, and *E. minutus* from the TEP. Based on detailed morphological evaluation, Ginsburg (1931) demonstrated that *E. minutus* and *E. lyricus* are sufficiently different to be considered as distinct species, but Brittan (1966) synonymized them on the basis

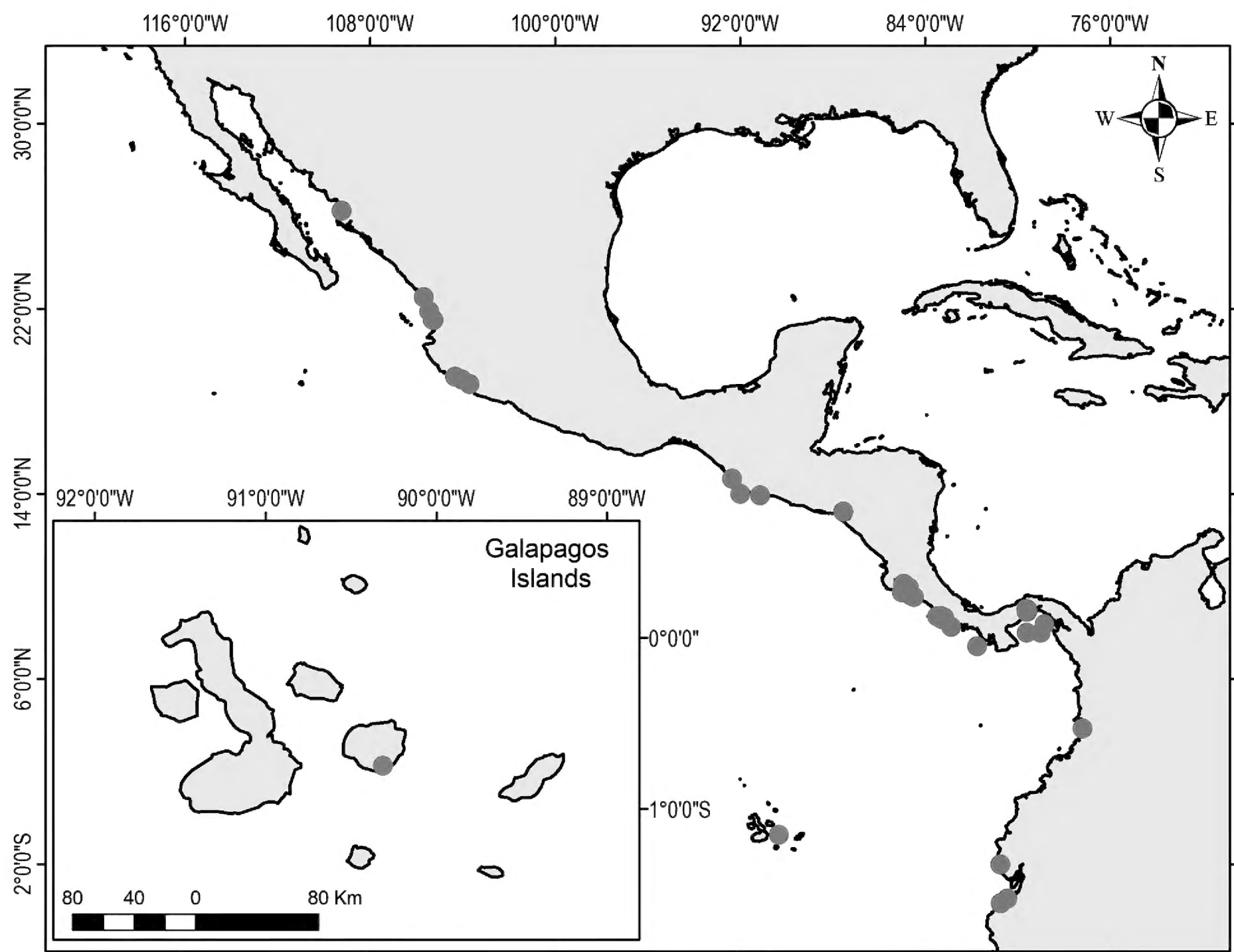


Figure 1. Records of *Evorthodus minutus* (blue dots) along Tropical Eastern Pacific, and newrecord (red dot) in Academy Bay, Santa Cruz Island, Galapagos.

of coloration of the body. Nevertheless, Tornabene et al. (2015) supported the differences observed by Ginsburg (1931) and estimated the divergence between of *E. lyricus* and *E. minutus* at 2.8 Ma, which coincides with the formation, during the middle- to late-Pliocene, of what is now the Isthmus of Panama (Thacker 2017). In both species, pelagic larval duration and other ontogenetic features are unknown (Borges et al. 2011); additionally, while *E. lyricus* has been widely studied in the Atlantic and Caribbean, *E. minutus* has been scarcely mentioned. Here, we provide a new record of *E. minutus* collected at the Santa Cruz Island, Galapagos Archipelago. Our record is 1,075 km from the closest record on mainland Ecuador. It represents the first record of this brackish-water species from an oceanic island.

Methods

During an extensive revision of gobies from the TEP hosted in the Ichthyological Collection of the California Academy of Sciences (CAS), we found a single specimen of *Evorthodus minutus* in a jar mixed with *Bathygobius lineatus* collected from tidepools of Santa Cruz Island, Galapagos Archipelago (Fig. 1) during the Templeton Crocker Expedition in 1932.

The identification of the specimen was corroborated using the original description, along with the identification keys of Robertson and Allen (2015) and Van Tassel (2012). We obtained morphometric measurements with a digital caliper with 0.1 mm of precision. A stereomicroscope was used for the determination of the meristic characters. Morphometric characters were expressed as percentages of the standard length (SL). Morphometric methods follow Sadeghi et al. (2017). Meristic abbreviations are as follows: D1 = first dorsal fin rays, D2 = second dorsal fin rays, V = ventral fin rays, A = anal fin rays, and P = pectoral fin rays. The specimen was recatalogued and is part of the Ichthyological Collection of the California Academy of Sciences.

Results

New record. Ecuador: Galapagos Archipelago: [SE shore of] Santa Cruz Island: long tidepools of Academy Bay (ca “-00.754120°, -090.286766°”), collected by H. Clark & F. Taiga (field number TCE 4-V-32; Templeton Crocker Expedition), 4 May 1932 (1 specimen, standard length: 19.93mm, female (Fig. 2); CAS 244480).

Identification. D1 = VI, D2 = I, 10, A = I, 11, P = 14. Morphometric data are provided in Table 1. Body elon-

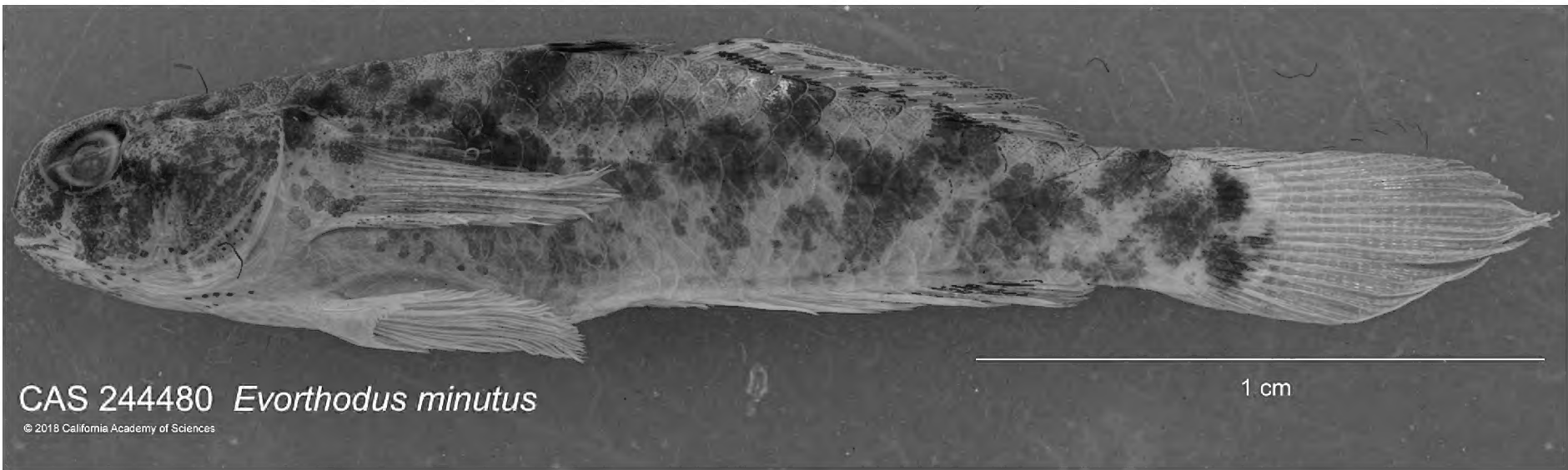


Figure 2. *Evorthodus minutus* collected in May 1932 from tidepools of Academia Bay, Santa Cruz Island, Galapagos (photograph: J. Fong).

Table 1. Morphometric characters of *Evorthodus minutus*, CAS 244480. All values except for total length (TL) and SL are proportions.

Morphometric measurements	Proportion
Total length (TL, mm)	26.88
Standard length (SL, mm)	19.93
Standard length (SL/TL)	0.74
Head length (HL/SL)	0.24
Body depth (BD/SL)	0.21
Snout length (SN/SL)	0.26
Eye diameter (ED/SL)	0.064
Predorsal distance length (PD/SL)	0.47
Pectoral length (PL/SL)	0.28
Pelvic lengthht (PeL/SL)	0.23
Caudal peduncle length (CP/SL)	0.13
Caudal fin length (CF/SL)	0.28
Anal fin base length (AFL/SL)	0.30
First dorsal fin length (FDL/SL)	0.11
Second dorsal fin length (SDL/SL)	0.30

gated, brown, with darker brown spots forming indistinct bars on the body: the first bar on the base of first dorsal fin and covering the first spines, the second bar on the posterior half of the second dorsal, and the third on the last rays of the second dorsal. Base of caudal fin with 2 spots: upper spot slightly darker and smaller than lower spot. Upper base of pectoral fin with another spot; lower base with several small brown spots. Head short, compressed; snout steeply rounded in profile. Eyes large, with 2 pores between them; 1 pore behind eye and 1 on preopercle. Head and nape with large scales. Head, cheek, preopercle and operculum with small brown dark blotches. Jaw slightly inclined. Union of jaws almost reaching iris. Edge of lower lip with a series of spots. Throat with a series of spots. Pelvic fin almost reaches anus. Pectoral, pelvic and caudal transparent; anal fin with brown spots on last 4 rays. First dorsal with a dark bar, second dorsal with at least 2 transverse brown lines. Tongue truncated; teeth with flattened, forked tips, in a single row on side of each jaw.

The specimen corresponds to the original description of *E. minutus* in the coloration on the body, markings (including the presence of 2 characteristic brown spots on the base of the caudal fin), size, body form and other

structures such as teeth, tongue and pores on the head.

Evorthodus minutus was found in a jar mixed with *Bathygobius lineatus* (Jenyns, 1841), an endemic species from the Galapagos Archipelago. *Bathygobius lineatus* has a total length of 12 cm, while *E. minutus* has a total length to a maximum of 3.6 cm (Robertson and Allen 2015). However, juveniles of *B. lineatus* tend to have small blotches on the body and caudal peduncle and could be confused with other cryptobenthic tidepools species, even with *E. minutus*. Probably, for this reason, *E. minutus* was not recognized from *B. lineatus*. However, *E. minutus* cannot be confused with *B. lineatus* because there are a large number of distinctive characteristics such as the form of the head (short and rounded in *E. minutus*), the first 5 superior rays (separate and bifurcate in *B. lineatus*), and the presence of 3 blotches behind the eye (in *B. lineatus*).

Discussion

Evorthodus minutus is a brackish-water shallow-dwelling species which inhabits intertidal zones to about 5 m on mud substrate of mangrove ecosystems (Robertson and Allen 2015); and sometimes, it can enter freshwater (Van Tassell and Findley 2010). This species is distributed in the TEP from Sinaloa, Mexico to southern Gulf of Guayaquil, Ecuador, and is usually found in mangrove ecosystems along the Central American coast. This specimen represents the first record of *E. minutus* from the Galapagos Archipelago and is 1,075 km from the nearest previous mainland Ecuador occurrence (Santa Elena, northern Guayaquil).

The record from the Galapagos, 1,075 km from the nearest previously known record on mainland Ecuador, raises the question about the connectivity pathways in the equatorial eastern Pacific and in particular from mainland Central America to oceanic islands such as Cocos, Malpelo, Gorgona and Galapagos. Based on genetic and biophysical modelling approaches, Lessios and Baums (2017) and Romero-Torres et al. (2018) showed that the most likely dispersal routes in the equatorial eastern Pacific is northward and southward along Central America by following the Costa Rica Coastal Current and the branch that feeds the Panama Gyre, the Panama Current,

and later the South Equatorial Current. As such, records of *E. minutus* north and south of 04° N on the Central American mainland might be explained by the dispersal of individuals carried the North Equatorial Counter Current that splits into 2 branches off the coast of Costa Rica. Based on a biophysical model, Lequeux et al. (2018) suggested that the islands of Malpelo and Gorgona serve as “stepping stones” between the mainland and offshore islands, such as the Galapagos. This suggests that the record of *E. minutus* from Santa Cruz Island might be the result of quasi-unidirectional larval flow from the continent to oceanic islands in the equatorial eastern Pacific.

Colonization by ballast water (Academy Bay is an important port) might also be responsible, such as for other vagrant marine species (sensu MacIsaac et al. 2016). However, the most likely hypothesis is by natural dispersal mechanisms (Sandel et al. 2011). Pinheiro et al. (2017) showed that “weak colonizers” are commonly composed by small species and tend to colonize oceanic islands using the seamounts as “stepping stones”, which leads to vicariance, as similarly observed in the genus *Tigrigobius* in the TEP (Hoese and Reader 2001). Pinheiro et al. (2017) suggested that persistence of new populations of weak dispersers depends on gene flow or, otherwise, these populations become extinct in a short time. This could be a reason for the apparent absence of records of the species in the Galapagos now. Nevertheless, the Santa Cruz record of *E. minutus* presents a new addition to the marine fish species from the Galapagos Archipelago and is the first record for a brackish-water species from an oceanic island in the TEP.

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Authors' Contributions

OVM examined and identified the specimen. All authors prepared, reviewed, finalized, and approved the manuscript.

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